Console Evaluation and Recommendations for CLCS

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Executive Summary

In September and October of 1997, a task-based evaluation (TBE) was conducted on four prototype CLCS consoles to identify design deficiencies and to develop a composite design that will be acceptable for implementation in CLCS. This report contains evaluations of postures observed during the TBE, comments contributed by the users during their participation in the TBE, and the opinions of the ergonomics team conducting the analysis. The results of the TBE suggest that the Venus prototype has the best overall layout. Several recommendations are enumerated to further improve this design. The TBE is limited by certain factors including the short term duration of the study, the restricted situations tested, the unfamiliarity of the users with the test OMI, and the artificial environment of the test area. Nevertheless, the recommendations contained here should assist in the specification of a final console design.

1.0 Introduction

This report will summarize the posture analysis for the four consoles being considered in the first round of task-based evaluations (TBE) for CLCS. The report will summarize the postures assumed by the system engineers who participated in the study, their interaction with the consoles, their opinions and preferences regarding the console designs, and the findings of the ergonomics team. Based on these results, a recommendation will be provided for a final console design.

2.0 Posture Analysis

The frequency of mild, moderate and severe postures observed during the practice OMI are summarized in Table 1. These values reflect the average incidence of each posture across all observed users. Incidents of severe postures are of particular concern because these are the postures that are likely to lead to injury or chronic discomfort from extended use. Moderate postures are those which are also somewhat likely to lead to injury or discomfort from extended use. It can be seen from Table 1 that the Mars console has a large number of severe postures. This is primarily due to the location of the monitors, requiring the user to simultaneously rotate and lift his/her neck. Distant reaches for control positions are also frequently needed. The Mercury console has a large number of moderate postures. These are in large part due to the height of the top row of monitors, thus requiring users to repeatedly look up and down when using the binders and the monitors together. This is the most frequent activity so is of great concern. The Neptune and Venus consoles do not require as many extreme postures. This indicates that the layout of the equipment in these two designs is superior to the Mars and Mercury consoles.

Mercury

	Mild posture	Moderate posture	Severe Posture
NECK	27	65	7
RIGHT SHOULDER	31	22	10
LEFT SHOULDER	6	4	0

Venus

	Mild posture	Moderate posture	Severe Posture
NECK	32	24	2
RIGHT SHOULDER	22	8	3
LEFT SHOULDER	9	3	0

Mars

	Mild posture	Moderate posture	Severe Posture
NECK	27	21	15
RIGHT SHOULDER	13	14	6
LEFT SHOULDER	2	1	0

Neptune

	Mild posture	Moderate posture	Severe Posture
NECK	28	18	9
RIGHT SHOULDER	27	16	3
LEFT SHOULDER	4	1	0

Table 1. Frequency of mild, moderate and severe postures of the neck and shoulders for each console. Numbers reflect the average across all users.

3.0 Design Deficiencies

This table summarizes number of users who reported problems with individual components of the console in the forced choice section of the survey.

Mercury		**Venus**		**Mars**		**Neptune**	
Monitor	80%	PFP	60%	Keyboard	70%	Deskspace	70%
OIS cords	35%	Telephone	60%	Deskspace	70%	Telephone	60%
Telephone	35%	Safing Panel	30%	Monitor	70%	OTV screen	50%
Safing panel	25%	OTV screen	30%	OTV screen	40%	OIS cords	25%
keyboard cords	25%	OIS cords	15%	Telephone	35%	Mouse cord	15%
mouse cords	25%			Lighting	30%		
OTV controls	20%			OIS controls	25%		
OIS controls	20%			OIS cords	25%		
				PFP	20%		

This table summarizes the number of *negative* comments contributed by **all** users. The full list of comments is located at the end of this report.

	Monitor	Console	PFP	Phone/cords	Keyboards/ Mouse
Mercury	**17**	**0**	**3**	**4**	**3**
Venus	**2**	**4**	**2**	**8**	**0**
Mars	**2**	**5**	**0**	**2**	**13**
Neptune	**10**	**14**	**1**	**3**	**14**

The following design deficiencies are only those that were reported by both system engineers and by the ergonomics team.

3.1 Mercury

- The top row is way too high. The large number of moderate neck postures is due to looking up at the monitor. They are not severe because there is no twisting required, however the repetitive nature of the movements can lead to significant discomfort. Many of the participants reported neck discomfort.
- Reaching distance to the OTV/safing panel is very large. This is due to the deep work surface as well as the placement of the equipment on the console.

3.2 Venus

- Many participants had difficulty viewing and reaching the CLCS Command Panel because of the two-tiered work surface.
- The two-tiered work surface also interfered with participants' ability to see the lower part of the bottom row of monitors. This may be a significant problem for shorter people.
- The telephone is in a poor location. Several participants had difficulty reaching it during the TBE.

3.3 Mars

- In order to manipulate equipment on the OIS/OTV/Safing panel rack while monitoring the C&C monitor, the operator needed to reach across the console. Because of the location of the OIS/OTV/Safing panel rack, the operator needed to rotate the chair or his torso nearly 45° and extend his shoulder more than 90° and twist his neck back in order to view the monitor. This awkward position is repeated many times throughout the evaluation.
- Access to the keyboards is cumbersome. Participants had difficulty removing the keyboard cover as well as replacing the cover after they had removed the keyboard. Most participants reported this as being a significant problem.
- There is not enough desk space on the console work surface. Most participants reported a significant deficiency in desk space.
- The safing panel and OTV controls are in a poor location. Many participants reported that reaching for this equipment was difficult.
- The telephone is in a poor location. Several participants had difficulty reaching it during the TBE.

- The top row of monitors is too high. There were a significant number of severe neck postures that are a direct result of neck flexion to view the top monitor. In addition, several participants reported discomfort in their necks at the end of the test.

3.4 Neptune

- The top row of monitors is too high. There were a significant number of severe neck postures that are a direct result of neck flexion to view the top C&C monitor. In addition, several participants reported discomfort in their necks at the end of the test.
- Access to the keyboards is cumbersome. Participants had difficulty removing the keyboard cover as well as finding a convenient place to store it.
- There is not enough desk space on the console work surface. Most participants reported a significant deficiency in desk space.
- The telephone is in a poor location. Most participants had difficulty reaching it during the TBE.
- The OTV is set back into the console too far to be easily viewed. Most participants reported difficulty viewing the OTV screen.
- The gooseneck lights often interfered with the view of the monitors. Participants had to repeatedly move them out of the way.

3.5 General Problems

- There was a significant amount of friction between the chair and the carpet. Many participants reported difficulty maneuvering the chair around the console.
- The upper row of monitors in each of the consoles is too high. The most prevalent postural problems were in the neck, primarily due to looking up at the top monitors.

4.0 Recommendations

The objective of this report is to refine the design specifications that would maximize the ease of use of the console while minimizing the potential musculoskeletal problems of long term use. The results of the TBE indicate that the basic layout preferred by participants is the Venus console. This is also the layout that had the least prevalence of severe and moderate postures. In order to eliminate the design deficiencies of the Venus console, the following recommendations are proposed:

- The greatest potential problem is in viewing and accessing the lower parts of the console, which can be obscured by the upper tier of the two-tiered work surface. This may particularly be a problem for shorter users. Two possible modifications can alleviate this problem. If the upper tier were lowered slightly, this would maintain the two-tiered effect, which is liked by many users, but reduce the obstruction. Alternatively, the lower monitor level can be raised slightly. Because of the distance between the two rows of monitors, this can be achieved without raising the overall height of the console. This would eliminate the viewing problem, although the reaching problem may still exist for shorter users.
- The phone should be moved to a more convenient location. Currently, it is inconvenient to reach. Because the phone is not used often, this is a low priority modification.
- In general, the upper level of monitors is at the limit of acceptability. If possible, design consideration should be given to lowering the height of these monitors.

Chair

Reducing the friction of the chair and the carpet may be achieved by using better casters. Also, a Plexiglas sheet can be placed in the area around the console. These will facilitate movement around the console.

5.0 Limitations

These recommendations are based on the initial TBE. This evaluation consisted of individual users who worked alone at the console. No analysis was possible of the effects of multiple users working simultaneously at the console. Also, the users had not previously interacted with a CLCS console. This lack of experience may cause the users to interact with the console in ways that will not occur in actual use conditions. Furthermore, the users were not working under time constraints. While they were instructed to complete the OMI at their usual work pace, it is difficult to simulate the stresses of launch day during a test. Finally, it was often observed that the users did not take the test seriously. They may not have completed the task in the same way that they would have under real work conditions. They occasionally made comments about one console on the survey for another console (for example, several users reported comments about the Mars console on the Venus survey). This was not always obvious, and so the comments tabularized at the end of the report may contain some incorrectly categorized items.

These recommendations are also based on a short term TBE. As the consoles are implemented in the HMF and LCC, it is recommended that long-term evaluation be conducted to further evaluate the console design. Long term evaluation of postures, discomfort and interaction with the equipment should be continued to evaluate the console design after the users become experienced at the console.

Summary of comments by all users/system engineers

Mercury

Monitors/CRT

• CRTs too high	17
• Liked the centered CCW screen	2

Keyboards/Mouse

• Too many keyboards and mice (3)	1
• Had difficulty retrieving keyboards; should be on sliding tray or fixed	1
• Thought keyboard storage is good	3
• Did not like keyboard storage	1
• Liked mouse driven OTV	2

Console

• Liked plenty of desk space	13
• Flat top better than Venus	1
• Liked task lighting	1

PFP / OIS / OTV

• Difficulty reading the meter	1
• Command Panel/PFP not labeled on screen (didn't like it)	1
• OIS panel too far to reach and to view	1

Phones/ Cords/ Headsets

• Did not liked phones on each end	1
• OIS headset should not have to cross desk	1
• phone too hard to reach	1
• OIS-D cord needs to be placed down & off the work station	1

Venus

Monitors/CRT

• Liked Angled or slanted screens	8
• Disliked slant panels away from user	2

Keyboards/Mouse

• Liked mouse driven displays	2

Console

• Liked two level desk	8
• Those who liked shelves for books above keyboard	6
• Didn't like top shelf	4
• Liked Desk space	2

CLCS Command Panel

• Command panel difficult to reach	2

Phones/ Cords/ Headset

• Phone a waste of space where it is	8

Mars

Monitors/CRT

- Business screen too high 2
- Liked screen resolution 4

Keyboards/Mouse

- Did not like keyboard storage 11
- Access to mouse difficult 2

Console

- Small desk space 5
- Good storage 2

PFP / OIS / OTV

- None

Phones/ Cords/ Headset

- OIS-D jacks not available 1
- Bad place for head set cord 1

Neptune

Monitors/CRT

- Stacked Screens Very easy to see 1
- Monitors were hard to read 6
- OTV is set in the console too far back 3
- Center console blocks view 1

Keyboards/Mouse

- Liked Recessed Keyboard 2
- I do like the mouse controls 2
- Didn't like moving the keyboard covers around 7
- Hidden keyboards cumbersome 7

Console

- Did not prefer lights on Neptune 4
- Liked the little lights 1
- Everything was easily accessible 1
- Not enough desk space 6
- No place to store books 2
- OIS plug-in hits leg 2

PFP / OIS / OTV

- The OIS-D, OTV, & Command/Safing Panel easiest to reach 2
- PFP "Safing Panel" can be covered by other windows 1

Phones/ Cords/ Headset

- Phone hard to reach 1
- Headset mounting is too close to the monitor 2